Comparative beach surveys using an unmanned aerial system, ground-based GPS, terrestrial laser scanning, and airborne laser scanning

Paul Elsner[1], Diane Horn[1], Uwe Dornbusch[2], Ian Thomas[3], Dan Amos[4], James Bovington[4]
Birkbeck College London[1], Environment Agency[2], Pevensey Coastal Defence Ltd[3], Strategic Regional Coastal Monitoring Programme[4]

AIMS OF THE RESEARCH PROJECT

- To compare accuracy of UAV-based surface modelling to terrestrial laser scanning and airborne laser scanning
- To test the potential of unmanned aerial systems for monitoring highly variable mixed sand and gravel beaches
- To evaluate the extent to which surface sediment characteristics affect measurement accuracy of TLS, ALS and UAV-based surface monitoring

Fig 1. PCDL managed beach

Fig 2. Location of Pevensey Coastal Defence Ltd

PEVENSEY COASTAL DEFENCE LTD

- PCDL is the first UK public-private partnership flood defence project
- contracted to manage 9 km stretch of coastline from 2000 to 2025
- protect against breach from 1:400 storm
- core requirements: 2 million m^3 of sediment distributed over 9 km frontage, minimum crest width 22m
- beach protects 50 km^2 against flood
- recharge from offshore, recycling sediment, winter reprofiling
- monthly GPS surveys since 2003
- composite mixed beach: reflective mixed sand and gravel upper beach, fine sand lower beach

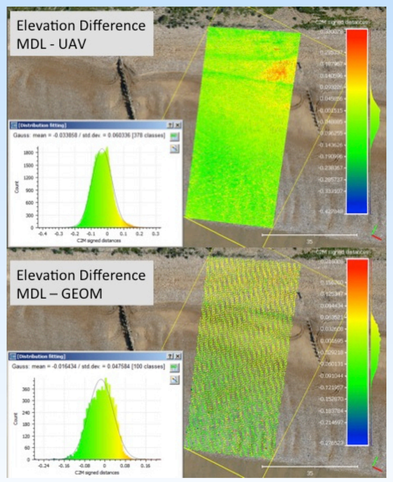

Fig 3. Elevation differences on dry beach UAV, GEOM(ALS), MDL(TLS)

Fig 4. UAV flight, laser-scanning and RTK-GPS platforms

DATA COLLECTION AND ANALYSIS

- UAV flying height 60 m above ground
- simultaneous measurements using UAV-based photogrammetry, RTK-GPS, quad-based TLS and ALS
- Complemented by RTK-GPS line transects
- point-cloud inter-comparison
- comparison of point-cloud performance against RTK transect data
- evaluation of differences between elevation models generated based on point clouds

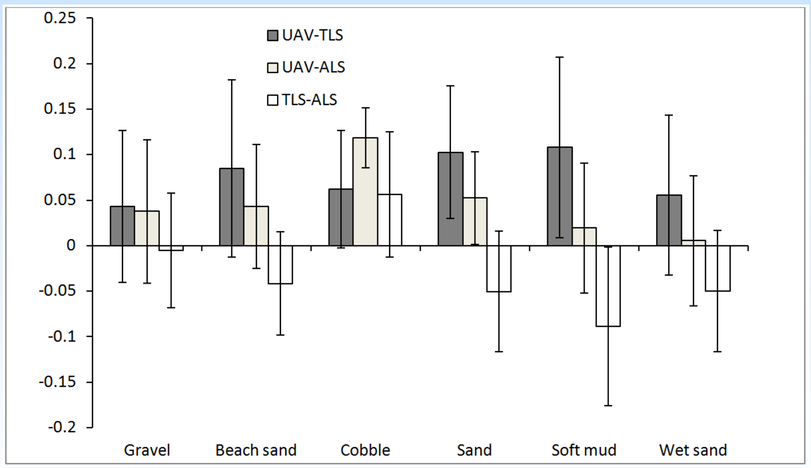

Fig 5. : Mean differences and RMS (bars) between point clouds depending on surface type

RESULTS

- UAV-based point cloud had positive offsets of 9 cm (RMS 10 cm) compared to TLS
- UAV-based point cloud had positive offsets of 6 cm (RMS 8 cm) compared to ALS
- Significant performance differences between surface types, with best results for gravel and dry sand and worst for soft mud surfaces
- UAV and ALS data overall showed better agreement than UAV to TLS for nearly all surface types

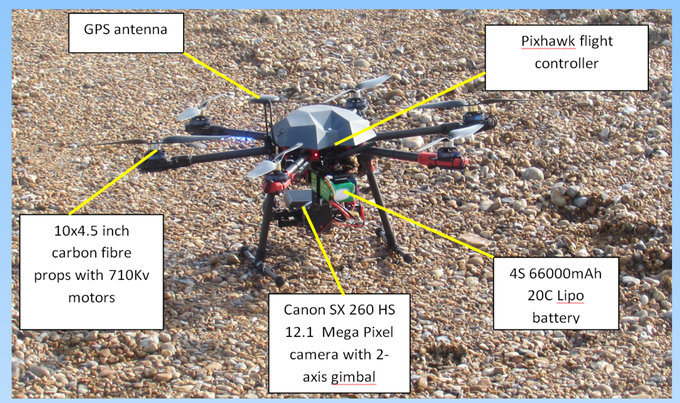

Fig 6. UAV set-up

CONCLUSIONS

- UAV appeared to systematically overestimate surface heights compared to laser scanning approaches but RMS is very similar
- Needs to be considered when comparing UAV data with laser-scanning-based elevations
- Overall UAV approaches show to be a robust method to detect ≥dm level elevation changes
- Promising approach to deploy UAV for surveys in high temporal resolution to monitor short-term elevation changes and to spatially resolve associated sediment fluxes
- Flight regulations and sensitivity to wind / weather conditions represent significant operational limitations

Please take reprints below or get a pdf from d.horn@bbk.ac.uk